

Technical Efficiency and Ownership

The Case of Booking Centres in the Swedish Taxi Market

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1. Introduction

The Swedish taxi market was deregulated on 1 July 1990. Since deregulation the market has changed in several ways, but the functional structure of the market is, in general, the same. As in most transport markets with relatively low density of demand some kind of middleman is used. For the taxi market these are referred to as booking centres. In an examined population of 200 booking centres, 78.5 per cent estimated that more than 90 per cent of all services were mediated by a booking centre.

Before deregulation, the local associations of operating taxi firms were, by legal arrangements, forced to belong to *one* booking centre and by law numbers of booking centres were restricted to one in what was referred to as a traffic area. Since each traffic area usually consisted of one municipality, local monopolies were developed. One of the reasons for the deregulation was to stimulate competition between booking centres, especially booking centres that mediated taxi services purchased by public authorities (for example, for education or health services). As an alternative to privately owned booking centres, publicly owned booking centres were established in the market.

Since both privately and publicly owned booking centres now exist in the market the question of competition on an equal basis arises. In this study we investigate the question of competition on an equal basis by comparing technical efficiency between the two types of ownership. If significant differences in technical efficiency exist between the two ownership groups it can be concluded that competition is not on an equal basis.

2. Theoretical Framework

In this study a non-parametric approach of measuring efficiency will be used. Calculating efficiency by solving a linear-programming problem is sometimes referred to as Data Envelope Analysis (DEA) (see, for example, Charnes, Cooper and Rhodes, 1978) or non-parametric measures (see, for example, Färe, Grosskopf and Lovell, 1985). The framework used here originates from Farrell (1957).

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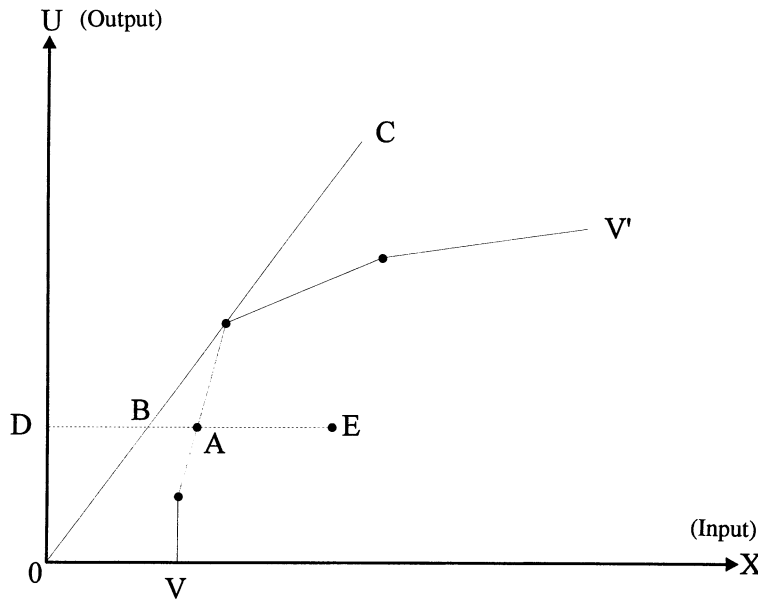


Figure 1

Illustration of Technical Efficiency when Imposing Different Scale Assumptions

The first problem is to calculate an efficiency measure for each observation, in this case a booking centre. This is done by constructing a hypothetical piece-wise linear reference technology. Those units that use the least amount of input to produce a given output will be used as references. By combining the reference points, using convex combinations, a set of hypothetical efficient input combinations, including the reference points, is received. This set is referred to as the "best practice frontier". The second step consists of comparing the actual observations with the reference technology. This is done by measuring the radial distance from the origin to the evaluated unit. The efficiency measure obtained by following these steps is referred to as a radial input-based measure of technical efficiency.

By restricting the weights in the programming problem, different efficiency measures are obtained and interpreted with different scale assumptions.

In Figure 1, E is the evaluated unit. The line $0-C$ corresponds to the best practice frontier, that is, the set generated by reference observations when imposing constant returns to scale. This will be referred to as long-run efficiency. A measure of long-run efficiency is obtained by calculating the distance $\|DB\|/\|DE\|$. The line $V-V'$ corresponds to the best practice frontier when imposing variable returns to scale, which will be referred to as short-run efficiency. A measure of short-run efficiency is obtained by calculating the distance $\|DA\|/\|DE\|$.

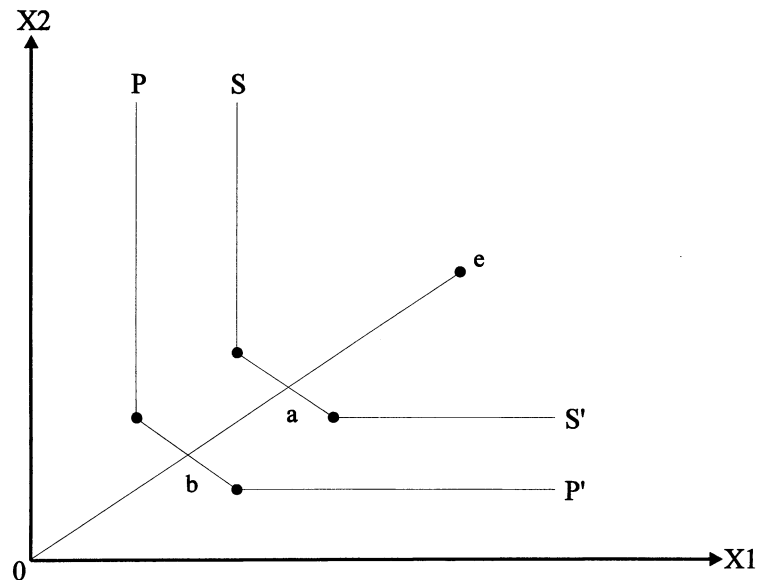


Figure 2
Illustration of Technical, Managerial and Organisational Efficiency
(input X1 and X2 are used to produce a given output)

Since the intention is to compare efficiency with respect to ownership, a decomposition of technical efficiency has been carried out. Following Grosskopf and Valdmanis (1987) a measure of separate, or managerial (Charnes, Cooper and Rhodes, 1981) efficiency is obtained by computing efficiency as above, but only using privately owned or publicly owned booking centres in the reference set. The results yield two different efficiency measures, one when using all observations, referred to as the pooled reference set, and one when only considering one type of ownership, referred to as the separate reference set. In Figure 2 the pooled reference set is illustrated by the isoquant $P-P'$, and the separate reference set is illustrated by the isoquant $S-S'$. By definition $S-S'$ is located above or on the isoquant $P-P'$.

The decomposition of the efficiency measure is achieved by dividing technical efficiency into two parts, *managerial efficiency* and *organisational efficiency*.¹ Managerial efficiency can be thought of as the inefficiency that can be affected by managerial behaviour, within the ownership group. Organisational efficiency can be thought of as that part of the efficiency measure that reflects different types of organisational structure.

First, technical efficiency can be illustrated as the distance between the evaluated observation e and the reference point b in Figure 2, and can be calculated as the distance $\|Ob\|/\|Oe\|$. Second, by computing a measure of technical efficiency but only using one type

¹ Grosskopf and Valdmanis (1987) refer to organisational efficiency as "between efficiency" and Charnes, Cooper and Rhodes (1981) refer to "programme efficiency".

of ownership, that is, privately *or* publicly owned booking centres in the reference set, a measure of managerial efficiency is obtained. Managerial efficiency can be calculated as the distance $\|O_{all}\|/\|O_{e}\|$, and is illustrated as the distance between e and a in Figure 2. Third, a measure of organisational efficiency can be obtained by a radial comparison between the separate reference set (a) and the pooled reference set (b). A measure of organisational efficiency can be calculated as:

$$\frac{\|O_b\|}{\|O_{e}\|} / \frac{\|O_{all}\|}{\|O_{e}\|} = \frac{\|O_b\|}{\|O_{all}\|}$$

This means that technical efficiency can be decomposed as:

$$\text{Technical Efficiency} = \text{Managerial Efficiency} \cdot \text{Organisational Efficiency} \quad (1)$$

To be able to answer the question of competition on an equal basis, the above framework suggests three different computations, with respect to the selection of a data set:

Computation 1: Efficiency calculated by using the pooled data set, that is, observations from both privately and publicly owned booking centres ($N=48$);

Computation 2: Efficiency calculated by using only privately owned booking centres ($N=33$);

Computation 3: Efficiency calculated by using only publicly owned booking centres ($N=15$).

For each computation, two different models are calculated: one imposing constant returns to scale, that is, long-run efficiency; and the other imposing variable returns to scale, that is, short-run efficiency. All computations are made under the assumption of strong disposability of inputs and outputs.

3. Data and Empirical Definitions

Since no previous study has been carried out with respect to the provision of booking centre services, some problems have to be solved. The first problem is to define input and output. Together with a reference group representing the actors in the market, input and output are defined as follows:

Output

U1 = Directly mediated services; that is, a consumer places an order, the order is registered and mediated. This output corresponds to the traditional order of taxi services through a booking centre.

U2 = Coordinated mediated services; that is, a consumer places an order, the order is registered, then coordinated and finally mediated. This output corresponds to a situation where the booking centre uses resources, for example, to coordinate several consumer trips to one vehicle.

Table 1
Summary Statistics of Input and Output in Production of Booking Centre Services

<i>Privately and Publicly Owned</i>					
<i>Variable</i>	<i>Mean</i>	<i>Standard Deviation</i>	<i>Minimum</i>	<i>Maximum</i>	<i>N</i>
U1	129168.29	109213.09	3000.0	420000	48
U2	45681.38	64619.72	0.0	250000	48
X1	5.48	4.72	0.5	30	48
X2	9.62	9.13	1.0	46	48
X3	2.91	1.82	0.5	8	48
<i>Privately Owned</i>					
<i>Variable</i>	<i>Mean</i>	<i>Standard Deviation</i>	<i>Minimum</i>	<i>Maximum</i>	<i>N</i>
U1	144622.61	111593.73	17500	420000	33
U2	30248.18	54455.70	0	250000	33
X1	4.84	2.95	1.00	15.00	33
X2	10.85	10.22	1.00	46.00	33
X3	2.33	1.47	1.00	7.00	33
<i>Publicly Owned</i>					
<i>Variable</i>	<i>Mean</i>	<i>Standard Deviation</i>	<i>Minimum</i>	<i>Maximum</i>	<i>N</i>
U1	95080.80	98828.71	3000.00	351000.00	15
U2	79634.40	73781.81	4500	198000	15
X1	6.87	7.20	0.50	30.00	15
X2	6.93	5.44	1.00	20.00	15
X3	4.17	1.92	0.50	8.00	15

Input

X1 = Labour, measured as those personnel employed with coordination and mediation of taxi services. Part-time employment is converted into its full-time equivalent.

X2 = Technical equipment, measured as the number of telephone lines.

X3 = Floor space, measured by the number of fixed working stations.

The second problem is that booking centres normally do not identify, much less measure, production. To be able to carry out the examination, with the objective of comparability, a sample of booking centres has to be used. In Sweden, approximately 250

booking centres exist, and 21 of these are owned and operated by municipalities or health care organisations. At the time of the study, 15 were fully operating and six had recently started. To measure production, estimations of the number of mediations were made by the personnel in the booking centres. These estimates were checked by a one-week mapping of production, and in some cases corrections of estimates were made together with personnel from the booking centre.

Since the problem in this study focuses on the comparison between privately and publicly owned booking centres, the aim of the selection process was to receive the largest possible comparability, with respect to size. In the market, 15 publicly owned booking centres were in full operation during the period of the study. These 15 booking centres were selected. Among the privately owned booking centres those that had the greatest similarity to a publicly owned booking centre with respect to size were selected to represent privately owned booking centres. Since in some cases more than one privately owned booking centre had the greatest similarity with one publicly owned booking centre, 33 privately owned booking centres were selected.² Table 1 shows summary statistics of input and output.

On average, publicly owned booking centres produce more coordinated mediations than privately owned ones, but the opposite is true for directly mediated services. This is not surprising since one of the aims of publicly owned booking centres is to coordinate mediations as far as possible.

For the inputs, it can be observed that both the number of full-time employees and the amount of floor space are larger for the publicly owned booking centres. Technical equipment, measured as the number of telephone lines, is on average higher for the privately owned booking centres, and the number of fixed working stations is on average higher for publicly owned booking centres.

4. Empirical Results

4.1 Technical efficiency

In Table 2 summary statistics are presented for the first computation, that is, using the pooled data set concerning technical efficiency.

The analysis of the pooled data set shows that inefficiency exists in rather large amounts, both in the long and the short run. The results of the analysis of the pooled technical efficiency show a mean inefficiency of 25 per cent in the short run and 41 per cent in the long run. The maximum amount of inefficiency, that is, one minus minimum efficiency score, are 74.5 per cent for the short-run model and 88.3 per cent for the long-run restricted model. According to Hjalmarsson and Veiderpass (1992) low efficiency scores indicate a lack of competition.

The results indicate that both in the long and in the short run the privately owned booking centres have a higher average efficiency, compared to the publicly owned ones.

² Only one privately owned booking centre responded that no coordinated mediations are carried out.

Table 2
Summary Statistics for Technical Efficiency using the Pooled Data Set as Reference
(numbers of observations used as a reference in parentheses)

	<i>Mean</i>	<i>Standard Deviation</i>	<i>Minimum</i>	<i>Maximum</i>	<i>N</i>
<i>Pooled</i>					
Short run (VS(48))	0.75	0.23	0.255	1.00	48
Long run (CS(48))	0.59	0.25	0.117	1.00	48
<i>Privately owned</i>					
Short run (VS(48))	0.77	0.21	0.404	1.00	33
Long run (CS(48))	0.61	0.24	0.197	1.00	33
<i>Publicly owned</i>					
Short run (VS(48))	0.71	0.28	0.255	1.00	15
Long run (CS(48))	0.54	0.29	0.117	1.00	15

Table 3
*Differences in Pooled Technical Efficiency between Privately and Publicly Owned
 Booking Centres: Mann-Whitney Test*

	<i>z (prob z)</i>	
	<i>Short run</i>	<i>Long run</i>
<i>Pooled</i>		
Privately owned vs. publicly owned	-0.554 (0.580)	-0.947 (0.344)

Nine privately owned and four publicly owned units were located on the short-run best practice frontier. Four privately owned and three publicly owned units were located on the long-run best practice frontier.

One reason for the relatively high amount of inefficiency could be that many of the publicly owned booking centres started close to the date of deregulation and have not yet been organised in the most efficient way. At the time of deregulation new technology was introduced in many of the privately owned booking centres and many went from totally manual operation to being fully computerised. Since it takes time to “fine tune” new technology, a degree of the inefficiency might be explained by these circumstances.

In order to test whether technical efficiency differs between ownership groups, a non-parametric test (Mann-Whitney U-test) of significance has been used. The results of the Mann-Whitney test show that there is no statistically significant difference in technical efficiency between the two kinds of ownership. The results are given in Table 3.

Table 4
Summary Statistics of Computed Managerial Efficiency Scores
(numbers of observations used as a reference in parentheses)

	<i>Mean</i>	<i>Standard Deviation</i>	<i>Minimum</i>	<i>Maximum</i>	<i>N</i>
<i>Privately owned</i>					
Short run (VS(33))	0.88	0.19	0.434	1.00	33
Long run (CS(33))	0.63	0.24	0.197	1.00	33
<i>Publicly owned</i>					
Short run (VS(15))	0.85	0.20	0.379	1.00	15
Long run (CS(15))	0.75	0.25	0.273	1.00	15

Table 5
Differences in Short-Run and Long-Run Managerial Efficiency
with respect to Ownership: Mann-Whitney Test

	<i>z (prob z)</i>	
	<i>Short run</i>	<i>Long run</i>
<i>Managerial</i>		
Privately owned vs. publicly owned	-0.460 (0.646)	-1.609 (0.108)

4.2 Managerial efficiency

In Table 4 summary statistics of managerial efficiency are presented. Even for managerial efficiency, the results show rather large amounts of inefficiency. Since managerial efficiency only compares units within the ownership group, a large amount of inefficiency indicates inefficient managerial behaviour. The results from comparing privately and publicly owned booking centres are somewhat ambiguous. For the short-run model private booking centres are more efficient, compared to publicly owned booking centres, but for the long-run model the results are the opposite, that is, publicly owned booking centres are more efficient than privately owned ones. The analysis of managerial efficiency shows that twenty privately owned booking centres are located on the short-run best practice frontier, and four on the long-run best practice frontier. For the publicly owned booking centres, eight were located on the short-run best practice frontier and six on the long-run best practice frontier.

Table 6
Summary Statistics of Organisational Efficiency Computed as the Ratio of Efficiency of the Pooled Data Set and Efficiency of the Separate Data Set

	<i>Mean</i>	<i>Standard Deviation</i>	<i>Minimum</i>	<i>Maximum</i>	<i>N</i>
<i>Privately owned</i>					
Short run (VS)	0.89	0.15	0.585	1.00	33
Long run (CS)	0.98	0.07	0.655	1.00	33
Number of efficient units: 16					
<i>Publicly owned</i>					
Short run (VS)	0.75	0.25	0.273	1.00	15
Long run (CS)	0.71	0.25	0.412	1.00	15
Number of efficient units: 6					

For the case of managerial efficiency a non-parametric test has been carried out. The results of the test are presented in Table 5. Both long-run and short-run results show that no statistically significant differences exist between the two types of ownership groups (90 per cent), even though the long-run results indicate higher managerial efficiency for publicly owned booking centres. The conclusion is that no significant differences are to be found when comparing managerial efficiency between privately and publicly owned booking centres.

4.3 Organisational efficiency

Organisational efficiency is defined as the distance between the pooled best practice frontier and the separate best practice frontier and is calculated as the ratio between the efficiency score of the pooled data set and the efficiency of the separate data set. One measure of short-run and one measure of long-run organisational efficiency have been computed. The summary statistics are presented in Table 6.

On average, organisational efficiency is higher for privately owned booking centres, both in the short and in the long run. The results indicate that the differences between the pooled best practice frontier and the separate best practice frontier are lower for the privately owned, that is, publicly owned booking centres have, on average, a greater organisational inefficiency.

To analyse differences in organisational efficiency with respect to ownership a Mann-Whitney test has been performed on the calculated organisational efficiency scores. The hypothesis to be tested is that organisational efficiency is the same regardless of ownership. The results are presented in Table 7.

Table 7
Differences in Short-Run and Long-Run Organisational Efficiency
with respect to Ownership: Mann-Whitney Test

	<i>Short run (VS)</i>	<i>Long run (CS)</i>
<i>Ownership</i>		
Privately owned vs. publicly owned	-1.029 (0.303)	-4.273 (0.000)

For the short-run results it is not possible to state that a difference exists, with respect to ownership (90 per cent). In the long run, though, this is possible. The results show that privately owned booking centres have a greater organisational efficiency compared to publicly owned booking centres, and that the difference is significant at a 99 per cent level. The interpretation of the results is that privately owned booking centres are significantly closer to the pooled best practice frontier when not taking managerial efficiency into consideration. One explanation for the results could be the fact that publicly owned booking centres have existed in the market for a shorter period of time.

The conclusion concerning organisational efficiency is somewhat ambiguous. In the short run no significant differences are found, but for the long-run results a significant difference exists.

5. Concluding Remarks

The purpose of this study was to investigate if competition between privately and publicly owned booking centres was on an equal basis. To be able to answer this question efficiency measures were calculated. Technical efficiency was decomposed into managerial efficiency and organisational efficiency. If it was possible to find significant differences between the two ownership groups the conclusion could be drawn that competition was not on an equal basis, since in this case systematically less efficient units are able to compete with systematically more efficient units in a competitive market. With regard to managerial efficiency no significant differences were found between the two ownership groups. For long-run organisational efficiency the results show that privately owned booking centres are significantly more efficient compared with publicly owned booking centres, but no significant differences were found when comparing short-run organisational efficiency. For the composed measure of technical efficiency no significant differences were found. Based on these results no unambiguous conclusions can be drawn, concerning differences in efficiency between the two types of ownership groups.

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